



U.S. House of Representatives
Committee on Transportation and Infrastructure

James L. Oberstar
Chairman

Washington, DC 20515

John L. Mica
Ranking Republican Member

David Heymsfeld, Chief of Staff
Ward W. McCarragher, Chief Counsel

May 14, 2007

James W. Coon II, Republican Chief of Staff

SUMMARY OF SUBJECT MATTER

TO: Members of the Committee on Transportation and Infrastructure

FROM: Committee on Transportation and Infrastructure Staff

SUBJECT: Hearing on 'Climate Change and Energy Independence: Transportation and Infrastructure Issues'

PURPOSE OF HEARING

On Wednesday, May 16, 2007, at 11:00 a.m., in Room 2167 Rayburn House Office Building, the Committee on Transportation and Infrastructure will receive testimony from witnesses testifying on climate change and energy independence issues for surface transportation, public buildings, aviation, and water resources and maritime transportation.

BACKGROUND

This memorandum summarizes climate and energy independence issues in surface transportation, public buildings, aviation, and water resources and infrastructure. The Committee on Transportation and Infrastructure held a hearing on Administration proposals on climate change and energy independence on May 11, 2007. An appendix at the end of this memorandum briefly summarizes climate change and its potential impacts.

Climate Change and Energy Independence Issues for Surface Transportation

According to the Environmental Protection Agency, 27.7 percent of the total greenhouse gas emissions produced by the U.S. come from the transportation sector, second only to electricity generation.

Highway and Transit

Federal Highway Administration (FHWA)

There are a number of programs in place to tie transportation decision-making to air quality, as well as programs to reduce vehicle emissions and encourage alternative forms of transportation.

Transportation Conformity—The Clean Air Act Amendments of 1990 and the Intermodal Transportation Efficiency Act of 1991 (ISTEA) established a close linkage between clean air goals and transportation investments. This linkage has been retained in subsequent surface transportation reauthorizations. The Clean Air Act requires that, in areas experiencing air quality problems, transportation planning must be consistent with air quality goals. This is determined through the transportation conformity process. Where air quality goals are not being met, sanctions on highway program funds may be imposed under the Clean Air Act as an incentive for areas to comply with air quality planning requirements.

Congestion Mitigation Air Quality Program—The Congestion Mitigation and Air Quality Improvement Program (CMAQ) provides funding for projects that contribute to air quality improvements and reduce congestion. It provides funds to State DOTs and MPOs to invest in projects that reduce emissions from transportation-related sources. In addition, CMAQ funding is often “flexed” to transit agencies to fund public transportation projects.

Eligible uses of CMAQ funds include: public transportation improvements, traffic flow improvements, transportation demand management, bicycle and pedestrian projects, alternative fuel projects, inspection and maintenance programs, intermodal freight transportation, public education and outreach, idle reduction technology, intelligent transportation systems, diesel retrofits for on-road motor vehicles and for non-road engines used in highway construction projects, purchase of integrated, interoperable emergency communications equipment, and advanced truck stop electrification. Construction of additional highway capacity, other than construction of high-occupancy vehicle lanes, is not eligible for CMAQ funds.

Transportation Enhancements—Transportation Enhancements (TE) provide funding opportunities to help expand transportation choices and enhance the transportation experience, including pedestrian and bicycle infrastructure and safety programs, scenic and historic highway programs, landscaping and scenic beautification, historic preservation, and environmental mitigation.

Nonmotorized Transportation Programs—Nonmotorized forms of transportation, such as walking or riding a bike, are inexpensive, widely practicable, and present a simple way for people to get from place to place in an environmentally friendly manner. Several federal programs are helping to encourage Americans to incorporate nonmotorized forms of transportation into their daily lives.

Nonmotorized Transportation Pilot Program—Section 1807 of SAFETEA-LU provides \$25 million over four years for each of the four participating communities: Columbia, Missouri; Marin County, California; Minneapolis, Minnesota; and Sheboygan, Wisconsin. Each of the four communities is working to create a nonmotorized transportation network, consisting of sidewalks, lanes, and pedestrian and bicycle trails that connect with transit stations, schools, residences, businesses, and community centers. The goal of this program is demonstrate the extent to which walking and bicycling can represent a significant portion of the transportation mode share, particularly when infrastructure is designed to make nonmotorized transportation easy and safe. The data resulting from this pilot will help to quantify the potential for mode shift.

The Safe Routes to School program—Established under section 1404 of SAFETEA-LU, this program provides \$612 million over four years for the states to establish programs to encourage kids to walk and bike to school. Each state receives a minimum of \$1 million, with remaining funds being awarded on the basis of student involvement. Funds can be used for a variety of infrastructure and educational purposes, including sidewalks, traffic calming, bicycle parking, traffic crossing improvements, public awareness campaigns, and student training in bicycle and pedestrian safety. The program requires states to appoint a full-time Safe Routes to School coordinator to oversee their state's program, and created a national clearinghouse to allow states to share information and successful strategies. By encouraging walking and biking to school, the program strives to create new, environmentally-friendly habits that today's children will learn and pass along to future generations.

Conserve by Bicycling program—This program, included in the 2005 Energy Policy Act, was authorized but never funded. If provided with the authorized level of funding, the program would make available \$6.2 million to create pilot projects in 10 communities throughout the U.S. Communities involved would use education and outreach to convert motor vehicle trips to bicycle trips. The program also would require each community to document energy savings achieved as a result of the program, and instructs the Secretary to work with the National Academy of Sciences to create an Energy and Bicycling Research Study. Currently there is a significant lack of data on the prevalence and impacts of nonmotorized forms of transportation; this program represents a strong step in creating data sets that would allow transportation officials to more accurately gauge the effects that bicycling as opposed to driving can have on the environment.

Federal Transit Administration (FTA)

The FTA administers federal funding to support a variety of locally planned, constructed, and operated public transportation systems throughout these systems. FTA assists communities in supporting public transportation by issuing grants to eligible recipients for planning, vehicle purchases, facility construction, operations, and other purposes.

Public transportation use conserves energy, reduces oil dependence and improves air quality.

According to the American Public Transportation Association:

- Current transit use reduces U.S. petroleum consumption by a total of 1.4 billion gallons of gasoline annually compared to single occupancy automobile use.
- If Americans rode transit at the rate of 10 percent of daily travel, the U.S. would reduce its dependence on oil imported from the Persian Gulf by more than 40 percent.
- Transit agencies are subject to regulations regarding emissions, scrap tires, vehicle air-conditioning systems, stormwater runoff from facilities, and hazardous waste management.
- Public transportation reduces pollution by producing 95 percent less carbon monoxide, more than 92 percent fewer volatile organic compounds (VOCs) and nearly half as much carbon dioxide and nitrogen oxides (NOx) for every passenger mile traveled as compared to traveling with private vehicles.
- Public transportation reduces annual emissions for pollutants that create smog, VOCs and NOx, by more than 70,000 tons and 27,000 tons respectively compared to single occupancy automobile use.

- Most rail transit vehicles emit little or no pollution because they are electrically propelled.
- Most buses, ferryboats and commuter rail locomotives increasingly use cleaner alternative fuels.

Transit Capital Investment Programs—The transit capital investment program provides capital assistance for three primary activities: new and replacement buses and facilities, modernization of existing rail systems, and new fixed guideway systems (New Starts). These systems provide local communities an effective means of increasing mobility and relieving congestion. According to the American Public Transportation Association, over 10 billion passengers used public transportation last year, the highest level since 1957.

Clean Fuels Grant program and the National Fuel Cell Bus Technology Development Program (NFCBTP)—These programs offer incentives for increasing alternative fuels use in the transit program. Both programs provide grant funds for capital costs, and NFCBTP also addresses certain operating costs, technical issues, and institutional issues for fuel cell vehicles. Clean fuel or alternative fuel vehicle-related equipment or facilities acquired under the grant programs currently have a 90 percent federal share of the net project cost.

Railroads

Railroads emitted 2.5 percent of the transportation sector's emissions total.

Freight Rail

In the past 26 years, railroads have made enormous fuel efficiency gains. In 2006, one gallon of diesel moved one ton of freight an average of 423 miles, the approximate distance from Washington, D.C., to Boston, Massachusetts. This is a 80 percent improvement since 1980, when one gallon of diesel fuel moved one ton of freight an average of 235 miles. The Association of American Railroads (AAR) attributes the increased fuel efficiency to new, high horsepower locomotives, improved information technology systems, reduced idling, and new locomotive crew training programs.

Railroads are also investing in new technologies for additional fuel efficiency and emissions reductions. For example, General Electric will soon unveil the world's first 4,400 horsepower mainline hybrid locomotive that will be capable of capturing energy dissipated during braking and store it in a series of sophisticated batteries. That stored energy can be used by the crew on demand—reducing fuel consumption by as much as 15 percent and emissions by as much as 50 percent compared to most of the freight locomotives in use today.

Railroads significantly reduce highway congestion. A single intermodal train can take up to 280 trucks (the equivalent of more than 1,100 cars) off our highways. The American Association of State Highway and Transportation Officials (AASHTO) found that if one percent of the long-haul freight that currently moves by truck in the U.S. moved by rail, fuel savings would be approximately 110 million gallons per year and annual GHG emissions would fall by some 1.3 million tons. If 10 percent of long-haul freight now moving by truck moved by rail instead, annual GHG emissions would fall by nearly 13 million tons.

In the 2005 Energy Policy Act, Congress authorized \$65 million in funding to develop a public-private research partnership to demonstrate railroad locomotive technologies that increase fuel economy, reduce emissions, and lower costs of operation.

Passenger Rail

Passenger rail can significantly help reduce congestion, GHG emissions, and energy consumption. The Texas Transportation Institute estimates the annual cost of highway congestion in the U.S. is \$63 billion for wasted time (3.7 billion hours) and wasted fuel (2.3 billion gallons) sitting in traffic. According to the Department of Energy's *Transportation Energy Data Book*, one full passenger train can take 250-350 cars off the road, for a GHG savings of 1,900-2,600 tons per year. If the passenger train's fuel included 10 percent biodiesel, the GHG savings would be 3,000-4,100 tons per year. Passenger rail also consumes less energy, with automobiles' energy intensity at 3,549 British Thermal Units (BTUs) compared to 2,751 BTUs for passenger rail.

The benefits of passenger rail can also be extended to congestion in the skies. According to the *Transportation Energy Data Bank*, commercial airlines consume 3,587 BTUs versus 2,751 BTUs for commuter rail or 2,935 BTUs for corridor trains. According to AASHTO, passenger rail is competitive with air travel for distances of 500 miles or less. Over 80 percent of all trips exceeding 100 miles in length are less than 500 miles.

Climate Change and Energy Independence Issues for Public Buildings

The General Services Administration (GSA) is the central management agency of the Federal Government. GSA was created in 1949, after the Hoover Commission recommended a central management entity for Federal personal and real property activities, telecommunications, and automatic data processing equipment. GSA owns more than 1,600 Federal buildings totaling 181 million square feet of space, which provide office space for 470,000 Federal workers. GSA leases 166 million square feet of space in 7,300 leased properties, which provides office space for 590,000 Federal workers. It also provides space in Federal buildings for child-care and telecommuting. The inventory ranges from 2,500-square-foot border crossing stations along the northern border, to million square foot courthouses located in major metropolitan areas.

GSA is required by both executive order and statute to reduce energy consumption in buildings under its custody and control, such as office buildings, warehouses, laboratories, and courthouses. GSA invests in energy retrofit projects as well as incorporating energy management into its business plans for construction and modernization projects for federally owned buildings.

The Architect of the Capitol is responsible to the United States Congress for the maintenance, operation, development, and preservation of the United States Capitol Complex, which includes the Capitol, the congressional office buildings, the Library of Congress buildings, the Supreme Court building, the U.S. Botanic Garden, the Capitol Power Plant, and other facilities. The Subcommittee has jurisdiction over construction and repair and alteration projects of the Architect of the Capitol (AOC).

Although the General Services Administration has a robust energy conservation program, the Subcommittee continues to monitor the design, construction, and repair and alteration practices

of the Public Building Service to ensure the latest energy conservation technologies and design plans are effectively incorporated into the overall building program.

Climate Change and Energy Independence Issues for Aviation

As demand for aviation services continues to grow, so too does aviation's impact on the environment. The Federal Aviation Administration (FAA) forecasts that airlines are expected to carry more than one billion passengers by 2015, increasing from approximately 744 million in 2006. At the same time, fuel costs are rising, causing air carriers to actively search for increased fuel efficiencies, which may have positive impacts on the environment. Fuel costs are also driving air carriers, airports and manufacturers to look at innovations in alternative fuels. In addition, many airports are trying to increase capacity while mitigating environmental impacts on the local communities they serve.

Climate Change and Energy Independence Issues for Water Resources and Maritime Transportation

Climate change could negatively impact water resources as well as water infrastructure. The U.S. government's interagency climate research program, the U.S. Global Change Research Program, has stated:

In many cases and in many locations, there is compelling scientific evidence that climate changes will pose serious challenges to our water systems.

Increased evaporation of surface water and decreased precipitation in some areas can lead to drought in some areas, as well as higher concentration of contaminants in surface water. Increased precipitation and extreme weather events can lead to increased runoff and contamination of surface water as well as an increase in water-borne disease outbreaks. A 2001 study in the *American Journal of Public Health* showed that between 1948 and 1994, 68 percent of all waterborne-disease outbreaks in the U.S. occurred after rainfall events that ranked in the top 20 percent of all precipitation events by the amount of water deposited. Climate change is anticipated to result in a higher frequency of extreme wet weather events in some areas. Sea level rise will result in increased saltwater intrusion into coastal aquifers and water supply intakes in rivers. Warmer water temperatures can result in increased microbial and algal growth in surface water and water distribution systems. Warmer winter temperatures and earlier springs can result in decreased snow-pack and earlier runoff from snow melt. Uncertainty does exist as to the specific location, timing, and magnitude of these anticipated impacts.

Design features for water infrastructure such as sewage systems, wastewater treatment facilities, drinking water facilities, ports, levees, and dams should take into account potential climate change impacts such as changes in temperature, temperature ranges, level and frequency of precipitation, coastal water levels, frequency and magnitude of storm surges, and wind speed. These changes could potentially create different stresses on infrastructure design than traditional or original designs.

The Subcommittee on Water Resources and Environment has fewer areas that fall under its jurisdiction that emit greenhouse gases than other Committee on Transportation and Infrastructure

subcommittees. As a result, where other subcommittees are considering mitigation efforts to reduce energy expenditures and greenhouse gas emissions, the Water Resources and Environment Subcommittee will focus on adaptation actions to address climate change impacts. Adaptation actions can help to reduce the severity and costs of climate change impacts, and can be viewed as risk-management strategies that can complement mitigation efforts. Among the areas that can be adapted to reduce climate change impacts are coastal zoning, land-use planning, building codes, and water infrastructure design (dams, wastewater treatment facilities, sewer infrastructure.)

The Subcommittee on Water Resources and Environment has jurisdictional authority over the processes used by wastewater treatment facilities. A by-product of these processes is methane gas – a greenhouse gas emission. The Subcommittee can explore whether incentives or controls over these emissions are prudent.

The Subcommittee on Coast Guard and Maritime Transportation has opportunities for mitigation and adaptation actions. Vessels and port facilities fall under its jurisdiction. In addition, adapting port infrastructure to better handle stresses (sea level rise, storm surges, changed storm frequency and magnitude) from climate change impacts can also fall under its purview.

WITNESSES

PANEL 1 – SURFACE TRANSPORTATION

Mr. Jonathan Lash
President
World Resources Institute

Mr. William W. Millar
President
American Public Transportation Association

Mr. Edward Hamberger
President
Association of American Railroads

Mr. Andy D. Clarke
League of American Bicyclists
Executive Director

Mr. Edward Hall
General Manager of Engine Technology
General Electric

Mr. Tom Rader
President
Colorado Railcar

Mr. Greg Cohen
President & CEO
American Highway Users Alliance

PANEL 2 – PUBLIC BUILDINGS

Mr. R.K. Stewart, FAIA
President
The American Institute of Architects

Mr. William Prindle
Executive Director
American Council for an Energy Efficient Economy

Mr. Jeff Harris
VP for Programs
Alliance to Save Energy

Mr. Chris O'Brien
Chairman
Solar Energy Industries Association

PANEL 3 – AVIATION

Mr. Jim May
President and CEO
Air Transport Association

Mr. Greg Principato
President
Airport Council International – North America

Mr. Michael McQuade
Senior VP for Science and Technology
United Technologies Corporation

Mr. Richard L. Altman
Facilitator
Commercial Aircraft Alternate Fuels Initiative Facilitator

PANEL 4 – WATER RESOURCES

Dr. Gerald E. Galloway
President
American Water Resources Association
On behalf of:
Glenn L. Martin Institute Professor of Engineering
University of Maryland

Mr. Brian Richter
Director
Global Freshwater Initiative
The Nature Conservancy

Mr. Alf W. Brandt
Principal Consultant
Committee on Water, Parks & Wildlife
State of California Assembly

Mr. Steve Fitzgerald
Chief Engineer
Harris County Flood Control District
Houston, Texas
On behalf of the:
National Association of Flood & Stormwater Management Agencies

Ms. Linda Strout
Deputy CEO
Port of Seattle
On behalf of the:
American Association of Port Authorities

APPENDIX

Climate Change

In February 2007, the Intergovernmental Panel on Climate Change¹ (IPCC) declared that evidence of atmospheric warming is “unequivocal”.² The IPCC also stated with “very high confidence”³ that human activities have resulted in global warming. The results of this warming may result – and to a degree may already be resulting – in sea level rise, increased hurricane and storm activity, changed precipitation patterns resulting in more frequent floods and droughts, among other potential impacts.

The IPCC defines climate change as “any change in climate over time, whether due to natural variability or as a result of human activity.”⁴ While some climate change can occur as a function of natural variability, the IPCC notes that the warming that has occurred, and is expected to continue, is “*very likely* due to an observed increase in anthropogenic greenhouse gas concentrations”⁵ which are a result of human activities such as industrial processes, fossil fuel consumption, and changes in land use, such as deforestation.⁶

Current and projected global warming occurs because of the “greenhouse effect.” The greenhouse effect is a natural process in which the atmosphere absorbs heat – resulting in a warm and habitable earth. Specifically, visible sunlight passes through the atmosphere without being absorbed. Some of the sunlight that strikes the earth is absorbed and converted to heat, warming the surface. The surface then emits some of this heat back into the atmosphere where it is absorbed by greenhouse gases such as carbon dioxide (CO₂), methane, and nitrous oxides, among others. For the previous 10,000 years, the greenhouse effect has produced an average global temperature of 57 degrees Fahrenheit. The absence of greenhouse gases would result in an inhospitable planet unable to support most life forms with an average temperature well below freezing.

Human activities that emit greenhouse gases to the atmosphere increase the amount of heat that gets absorbed before it could otherwise escape into space. Anthropogenic, or human, emissions of greenhouse gases therefore enhance the natural greenhouse effect and cause global warming.

¹ Recognizing the problem of potential global climate change, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988. It is open to all members of the UN and WMO. The role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. The IPCC does not carry out research nor does it monitor climate related data or other relevant parameters. It bases its assessment mainly on peer reviewed and published scientific/technical literature.

<http://www.ipcc.ch/about/about.htm> (accessed 9 May 2007)

² IPCC, February 2007. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. p.5

³ The IPCC uses “the following levels of confidence...to express expert judgments on the correctness of the underlying science: *very high confidence* at least a 9 out of 10 chance of being correct; *high confidence* about an 8 out of 10 chance of being correct.” IPCC, February 2007. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. p.5.; Virtually certain >99% probability of occurrence, Extremely likely >95%, Very likely >90%, Likely >66%... *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. p.4.

⁴ IPCC, February 2007. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. p.2

⁵ IPCC, February 2007. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. p.10

⁶ IPCC, February 2007. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. p.2

It is without question that global warming has occurred, and is occurring. Average surface temperatures have increased by an estimated 1.4 degrees Fahrenheit between 1900 and 2005. Eleven of the last 12 years (1995-2006) rank among the 12 warmest years of global surface temperature⁷ since 1850.⁸ Other observations of observed climate change include:⁹

- The IPCC estimates that the total 20th Century sea level rise is 0.17 meters (.55 feet). They have “high confidence” that observed sea level has increased from the 19th to the 20th centuries;
- Average Arctic temperatures have increased at almost twice the global average rate in the past 100 years;
- Satellite data since 1978 shows that annual average Arctic sea ice extent has shrunk by 2.7 percent per decade;
- Temperatures in the Arctic permafrost layer (including areas of Alaska) have increased since the 1980s, and the maximum area covered by seasonally frozen ground has decreased by about 7 percent in the Northern Hemisphere since 1900;
- Precipitation changes have taken place including increased precipitation events in eastern sections of North and South America, northern Europe, and central Asia, and drying or drought events in the Sahel, the Mediterranean, southern Africa, and sections of south Asia;
- Increased frequency of heavy precipitation events over most land areas;
- Increased frequency of high-intensity (category 4 and 5) tropical cyclones (hurricanes) globally since 1970 as a function of increased sea surface temperatures among other factors.

The IPCC reports that:

Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture.¹⁰

The figures below are from the 2007 IPCC report and show the observed increases in greenhouse gases over time.¹¹

⁷ The average of near surface air temperature over land, and sea surface temperature. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. p.5

⁸ IPCC, February 2007. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. p.5

⁹ IPCC, February 2007. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. pp.7-8; Emanuel, K.A. 2005. “Increasing Destructiveness of Tropical Cyclones Over the Past 30 Years.” *Nature*. 436; 686-88; Webster, P.J., et al. 2005. “Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment, Science.” *Science*. 309: 1844-46.

¹⁰ IPCC, February 2007. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. p.2

¹¹ IPCC, February 2007. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. p.3

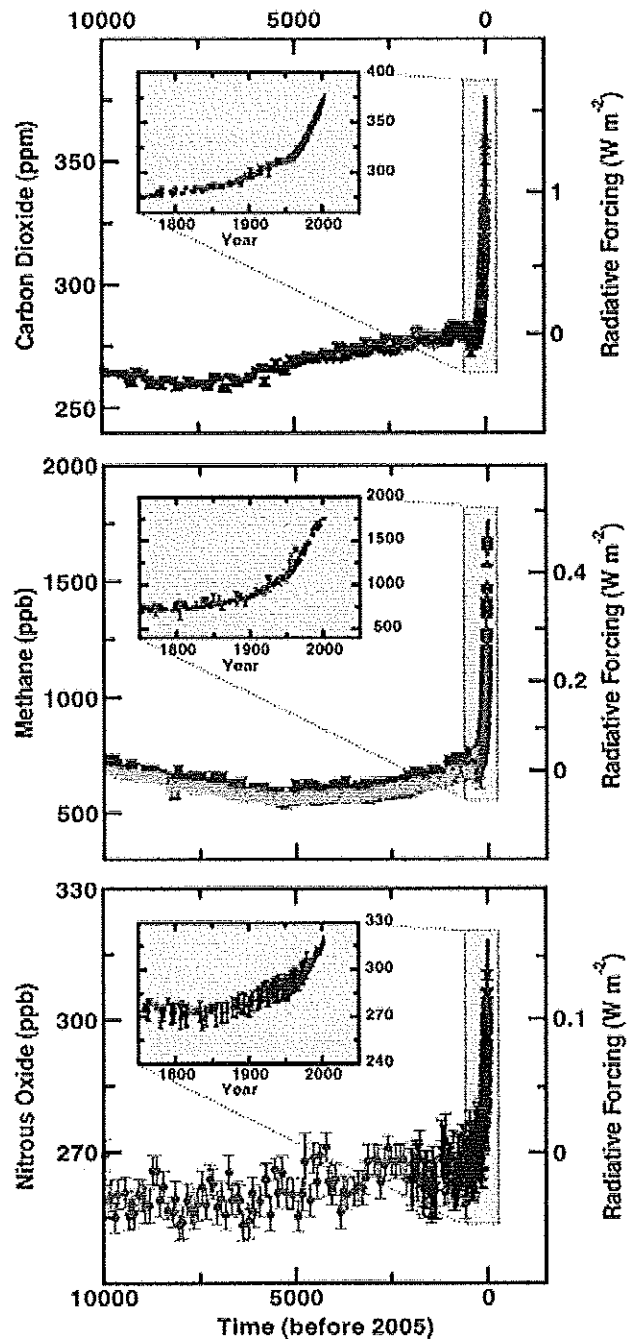
While a variety of greenhouse gases play a role in atmospheric warming, carbon dioxide is the most common and “the most important anthropogenic greenhouse gas.” Prior to 1800, the beginning of the Industrial Revolution (when fossil fuels, such as coal, began to be used on a wide scale), there were roughly 280 parts per million (ppm) of CO₂ in the atmosphere.¹² In 2005, 379 ppm of CO₂ were measured in the atmosphere. This “concentration of carbon dioxide in 2005 exceeds by far the natural range over the last 650,000 years (180 to 300 ppm) as determined by ice cores.” As a result of these increasing levels, carbon dioxide is attributed to account for approximately 80 percent of all observed global warming.

Other greenhouse gases do play an important part in observed global warming. Methane had a pre-industrial (pre-1800) value of around 715 ppb in the atmosphere. In 2005 it was measured at a level of 1,774 ppb. Methane is around 60 times more effective at capturing heat energy than CO₂. However, it lasts fewer years in the atmosphere than CO₂, and is produced in significantly lower amounts. It is estimated that methane will account for 15 to 17 percent of all global warming experienced this century. Nitrous oxide concentration has increased from a pre-1800 level of approximately 270 ppb to 319 ppb in 2005.

The IPCC projects that “continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would *very likely* be larger than those observed during the 20th century.”¹³

Climate Change Impacts

The IPCC projects a number of environmental, ecosystem, and public health impacts will take place as a result of climate change.



¹² Ppm (parts per million) or ppb (parts per billion) is the ratio of the number of greenhouse gas molecules to the total number of molecules of dry air.

¹³ IPCC, February 2007. *Climate Change 2007: The Physical Science Basis – Summary for Policymakers*. p.13

For example, climate scientists hold that an increase in sea surface temperature – driven by climate change – will likely result in an increased frequency of higher intensity (categories 4 and 5) hurricanes.¹⁴ While the deadly hurricane season of 2005 cannot be directly linked to changes in the earth's climate, it does echo these concerns. In just one storm, Hurricane Katrina, 1,118 people were confirmed dead, and 135 are still missing and presumed dead. Direct damage to residential and non-residential property is estimated at \$21 billion. Damage to public infrastructure is estimated at another \$6.7 billion. Almost one-half of the region's population that was affected by the storm has still not returned to their homes. And nearly 124,000 jobs were lost as a result of the hurricane.¹⁵ The impacts of Hurricanes Katrina and Rita might be considered a harbinger of future economic and human impacts as a result of climate change.

Observed and anticipated impacts cited by the IPCC include:¹⁶

- Increased heat-related mortality has been observed in Europe;
- Disturbed forests due to increased incidences of fire and pests;
- Coastal flooding impacts due to sea level rise, and increased frequency and/or severity of storms;
- Average annual river runoff and water availability is projected to increase by 10-40 percent at high latitudes and in some wet tropical areas;
- Average annual river runoff and water availability is expected to decrease by 10-30 percent in some presently dry regions in the mid-latitudes, and in the dry tropics;
- Heavy precipitation events will increase in frequency, adding to flood risk;
- Water supply storage in glaciers and snow pack will decline. This decline is anticipated to reduce water availability in regions supplied by melting snow from major mountain ranges – home to one-sixth of the world's population;
- Approximately 20-30 percent of plant and animal species are likely to be at increased risk of extinction if global average temperature increases exceed 1.5-2.5 degrees Celsius;
- Acidification of the ocean due to increasing CO₂ is expected to have negative impacts on marine shell forming organisms (shellfish and corals) and their corresponding ecosystems;
- Crop productivity is projected to increase slightly in mid to high latitudes and spring planting seasons may begin earlier in some areas. Crop production is expected to decrease in the tropics;
- Coastal wetlands will be negatively affected due to sea level rise, and decrease in sediment;

¹⁴ Emanuel, K.A. 2005. "Increasing Destructiveness of Tropical Cyclones Over the Past 30 Years." *Nature*. 436; 686-88; Webster, P.J., et al. 2005. "Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment, Science." *Science*. 309: 1844-46.

¹⁵ American Society of Civil Engineers – Hurricane Katrina External Review Panel. 2007. *The New Orleans Hurricane Protection System: What Went Wrong and Why*.

¹⁶ IPCC, April 2007. *Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability – Summary for Policymakers*. Pp.4-8